Retrofit SCR System for NO_X Control From Heavy-Duty Mining Equipment

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Presentation Outline

- Background
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- SCR System Description
- SCR Retrofit Examples
- Case Study – Installation of SCR Retrofit System in an Underground Mine

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Background

Diesel engines are the primary workhouse for the mining industry. While diesel engines have many advantages, they have the disadvantage of emitting particulate matter (PM) and oxides of nitrogen (NO_X).

Great concern about PM and NO_2 in an underground mine is leading to the use of diesel exhaust aftertreatment systems such as diesel particulate filters (DPF) and selective catalytic reduction (SCR).

As established by MSHA/ACGIH, in a mine the exposure of nitrogen dioxide (NO_2) and carbon monoxide (CO) cannot exceed 5/3 parts per million (ppm) and 50 ppm/25 ppm respectively.

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Why NO_X Control

Nitrogen oxides (NO_X), one of the most troublesome emissions from the diesel engine, is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. NO_X contributes to:

- the formation of ground-level ozone (smog) – which can trigger respiratory problems
- the formation of acid rain
- atmospheric particles, that cause visibility impairment
- nutrient overload that deteriorates water quality
- reactions which form toxic chemicals

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NO_X in Underground Mining

- NO_X is composed of **nitric oxide** (NO) and **nitrogen dioxide** (NO_2)
- NO_2 is the main concern in underground mines
- Diesel engines are a major source of NO_2 emissions in mines
- NO_2: NO_X ratio:
  - About 5% in naturally aspirated engines
  - Up to 15-20% in turbocharged engines

Options for NO_X Control

Technology	NOx Reduction	Comments
Engine Repower or Upgrade	80% on-road 60% off-road	Ultra-low NOx engines available only in 2010 (on-road) and ~2014 (off-road).
Exhaust Gas Recirculation (EGR)	30-40%	Applicable mostly to OEM applications. Retrofit application is problematic.
Lean NO_X Catalysts (HC-SCR)	10-50%	Higher conversions possible only in active systems with fuel injection. Fuel economy penalty.
NO_X Adsorbers (Traps)	50-80%	Applicable to OEM applications only. Require tight integration with the engine management system.
Fuel Emulsions	10-20%	Negative engine performance impact. Limited to centrally fueled fleets.
Selective Catalytic Reduction (Urea-SCR)	65-90%	Widely used in OEM applications. Retrofit systems in the process of EPA verification.

Selective Catalytic Reduction (SCR)

SCR has emerged as the preferred solution for reducing NO_X in heavy-duty vehicles. NO_X is reduced over the SCR catalyst through chemical reactions with a reducing agent, such as urea (commonly referred to as DEF in North America). Urea solution is carried in an onboard tank and injected upstream of the SCR catalyst.

- Typical reaction is given below:

  $4\ NH_3 + 4\ NO + O_2 \longrightarrow 4\ N_2 + 6\ H_2O$

- The final products are nitrogen (N_2) and water (H_2O)

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BlueMAX™ SCR System

Nett BlueMAX™ is a retrofit urea-SCR system designed to control oxides of nitrogen (NO_X) emissions from diesel engines in on-road, non-road, mining, and stationary applications.

The urea dosing strategy is based on engine-out NO_X emissions measured with a NO_X sensor before the SCR catalyst. The sensor based control strategy makes the system suitable for both original equipment and retrofit applications.

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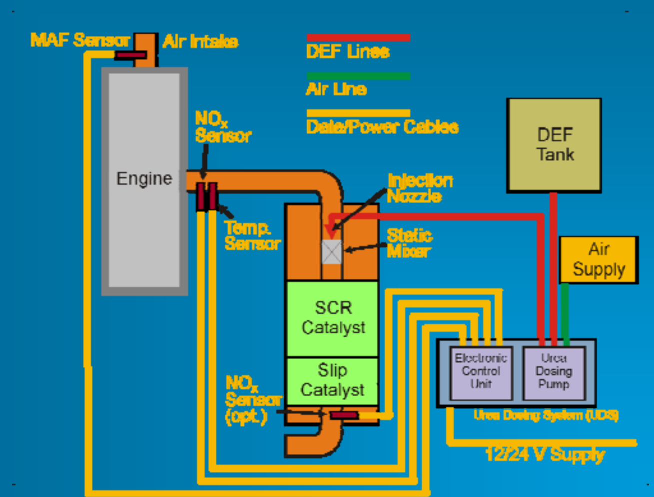
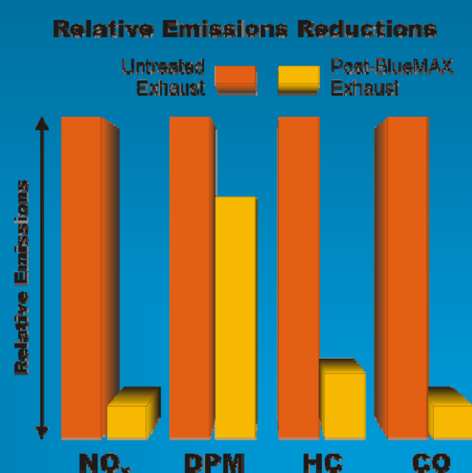
BlueMAX™ System Diagram

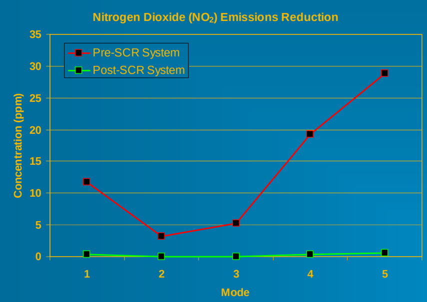


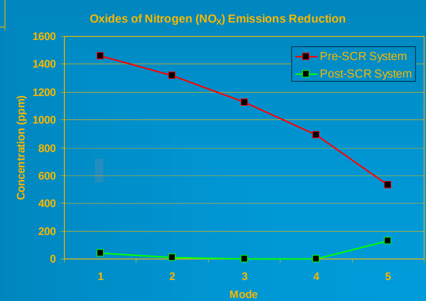
SCR System Performance

- 65-90% NO_X reduction
- Temperature range 250-600°C
- Minimal increase in back pressure
- Combination with diesel particulate filter available



Emission Data – Test Cell Results





ISO 8178 D2

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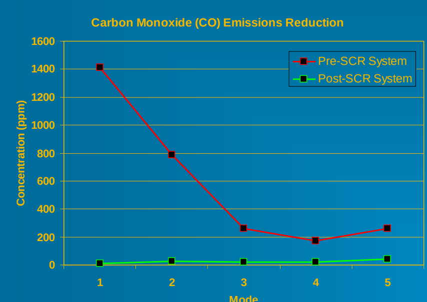
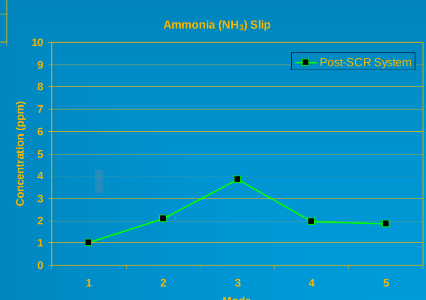
Emission Data – Test Cell Results





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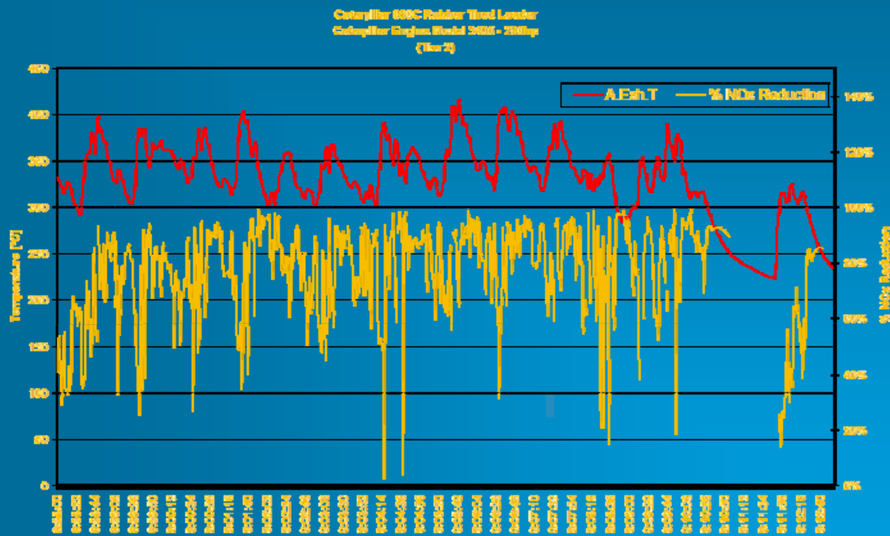
Emission Data – In-Use Results



Urea Consumption

The Nett BlueMAX™ system requires that aqueous urea solution (in the form of a 32.5% water-based solution) be carried in an on-board storage tank and that it is periodically replenished.

Urea consumption can vary from 1-5% (by vol.) relative to the diesel fuel consumption. For every 1g/bhp-hr of NO_X that is reduced, the amount of urea consumed is equal to ~0.9% of the diesel fuel consumed. So a 2g/bhp-hr NO_X reduction would require a urea consumption of approximately 1.8% relative to the diesel fuel consumption.

SCR Retrofit Examples

Caterpillar 980C Loader
BlueMAX™ SCR System

Caterpillar 330B Excavator
BlueMAX PLUS™ SCR System

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SCR Retrofit Examples

Volvo 64FT Transfer Truck
BlueMAX™ SCR System

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Case Study – SCR Retrofit Installation Underground Mine

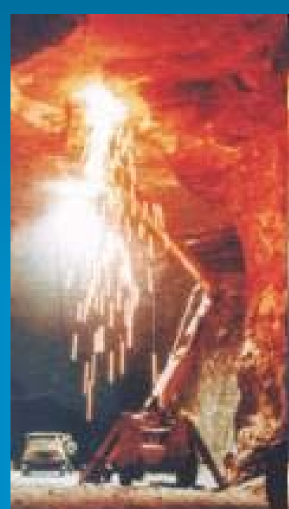
This section of presentation summarizes Sifto Canada Corporation collaborative effort with CANMET Mining and Mineral Science Laboratories to reduce emissions from diesel engines.

The objective of this demonstration and evaluation effort is to identify cost effective retrofit solutions to lower NO_2 emissions from heavy-duty trucks operating in underground mines.

Sifto Salt

Sifto Salt, a division of Sifto Canada Corp., is located in Goderich, Ontario and presently employs over 500 people.

The mine is at a depth of 1,800 ft below surface and extends 5 km under the lake Huron. The ceilings in the production areas are 60 ft high.



Candidate Vehicle

Caterpillar 775E Mining Truck	
Engine make	Caterpillar
Engine model	3412 E
Engine hp	544 kW (730 hp)
Displacement	27L
Model year	2005

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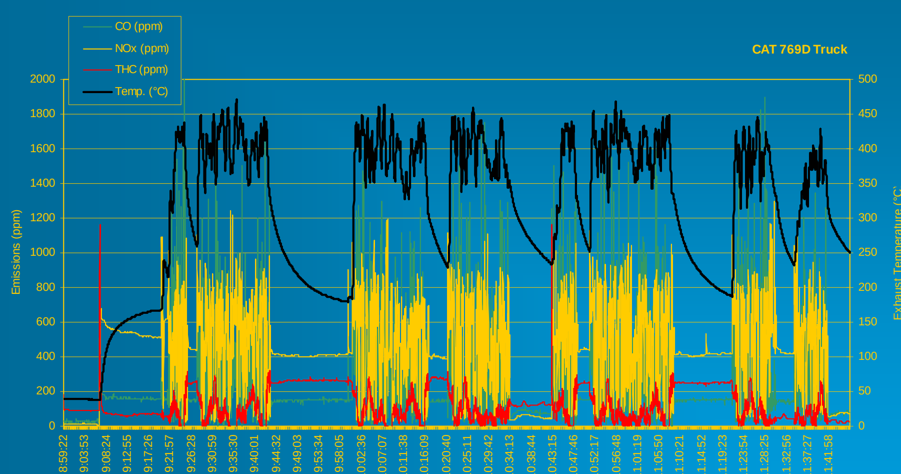
Baseline Emissions



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SCR Retrofit Solution - BlueMAX™

Original Muffler System

Caterpillar 775E Mining Truck
Sifto Salt

Nett BlueMAX™ SCR System

BlueMAX™ Installation – 775E

DEF Tank

Dosing Unit

BlueMAX™ Installation – 775E

Nett BlueMAX™ SCR Retrofit System

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